New evolutionary scenarios for short orbital period CVs.

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Abstract

We suggest new evolutionary scenarios for non-magnetic short orbital period CVs. The first model is the analogy of the 'hibernation scenario' or the 'modern hibernation scenario'. The second one is an extension of Mukai & Naylor (1995) ideas. All models imply a tight connection between permanent superhump systems and classical novae. We highlight the significance of the observed evolution of V1974 Cyg, which might pose a major problem to Mukai & Naylor concept.

1. Introduction

The 'hibernation scenario' (Shara 1989 for review) suggests that dwarf novae → nova-likes → novae → nova-likes → dwarf novae → hibernation → dwarf novae etc. However, it was later proposed that the hibernation stage ($\dot{M} \sim 0$) might not exist at all (Livio 1989), thus dwarf novae → nova-likes → novae → nova-likes → dwarf novae... The typical time scales for the transitions were estimated as a few centuries.

An alternative view to the 'hibernation scenario' was presented by Mukai and Naylor (1995). They suggested that nova-likes and dwarf novae constitute different classes of pre-nova systems. Therefore, there are two possibilities: 1. nova-likes → novae → nova-likes... 2. dwarf novae → novae → dwarf novae... Nova-likes should have more frequent nova outbursts than dwarf novae because their mass transfer rates are higher. The critical mass for the thermonuclear runaway is thus achieved much faster. According to this model, a long-term evolution between the two phases might occur.

2. Discussion

2.1. Permanent superhump novae

We note the similarity between long and short orbital period CVs. Permanent superhump systems have thermally stable accretion discs as do nova-likes, while SU UMa and U Gem systems are thermally unstable.

So far only two non-magnetic novae below the period gap have been discovered - CP Pup 1942 and V1974 Cyg 1992. Both have permanent superhumps in their light curves. To these systems, we naturally add V603 Aql 1918, the third permanent superhump nova, whose binary period is just the other side of the gap (Retter & Leibowitz 1998). These three objects show clearly that certain classical novae become permanent superhump systems. Since the three post-novae are permanent superhumpers, their accretion discs should be thermally stable. When we compare, however, the pre-outburst luminosities with the post-nova values, various types of behaviour are discovered. V603 Aql seems to have returned exactly to its pre-outburst magnitude. The upper limit on the brightness of the progenitor of CP Pup (Warner 1995) shows that it was fainter than its post outburst quiescent value, but prevents a precise decision concerning the thermal stability of the pre-nova. V1974 Cyg is the most interesting case among the three. Retter & Leibowitz (1998) argued that the pre-nova was faint, and therefore should have been a dwarf nova (SU UMa system) with a thermally unstable accretion disc. It is thus the only clear case of a classical nova that has changed its thermal stability state – a change to the thermally stable state from the thermally unstable state have been caused by the nova outburst. CP Pup might be a second example of this transition.

2.2. Summary of relevant observations

Observations of novae have shown the following:

1. Most systems probably have only a short cycle (nova-likes → novae → nova-likes... – i.e. Robinson 1975). Two selection effects might, however, be involved – brighter novae are better covered, and a longer observational base line might show a larger cycle.
2. There are two clear examples of novae that have turned into dwarf novae – V446 Her (Honeycutt et al. 1998) and GK Per (Sabbadin & Bianchini 1983). GK Per is, however, not a typical nova.
3. There is at least one example of a nova like (permanent superhump system) – V1974 Cyg, that should have been a dwarf nova (SU UMa system) before its nova event (Retter & Leibowitz 1998).

2.3. New evolutionary scenarios

We suggest that most (or perhaps all) non-magnetic short orbital period novae should evolve into permanent superhump systems. We also propose that most (or all) permanent superhump systems are ex-novae. An indirect evidence, supporting the last claim, is the fact that permanent superhumps have been detected in a few SW Sex stars (Patterson 1999), and three SW Sex candidates are actually old novae (Hoard 1998). Further evidence for this idea comes for the possible identification of BK Lyn, a permanent superhump system (Patterson 1999), with a Chinese guest star, which erupted in 101 (Hertzog 1986).

We further suggest that evolutionary scenarios, similar to those offered for the long orbital period CVs, are applicable to the short orbital period systems, as well. The equivalence of the 'hibernation scenario' is: SU UMa systems (→ permanent superhump systems) → novae → permanent superhumpers → SU UMa systems → hibernation → SU UMa systems... The analogy of the 'modern hibernation scenario' is: SU UMa systems (→ permanent superhump systems) → novae → permanent superhumpers → SU UMa systems... The extension of the two options of Mukai and Naylor (1995) ideas is: permanent superhumpers → novae → permanent superhumpers... and SU UMa systems → novae → SU UMa systems... The observed evolution of V1974 Cyg is consistent with this view only if the CV was caught in a very specific point in its long term evolution – a transition from the faint stage to the bright stage.

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